

Office of Technical Assistance Research Proposal
Separation of Aqueous Azeotropes

Background

Many companies in the state use volatile organic compounds (VOCs) in the formulation of media for reactions in the manufacturing of their products. In a lot of situations, the VOCs are never recovered because of cost and convenience. The recovery of these VOCs can make a substantial positive impact to the economics of their operations, especially if the recovery can be achieved at minimal cost. In some facilities, the VOCs are mixed with natural gas and destroyed by combustion in thermal oxidizers. The proposal is to recover the VOCs by scrubbing effluents from the ovens or other point of generation with water and then separate them from water using processes that are not too complicated. Some of the VOCs form binary azeotropes with water. Breaking the azeotropes can be quite challenging especially if the desirable component is present in low concentration and has low economic value. For some of the common chemicals though, the azeotropic mixtures are rich in the volatile organic compounds. The following chemicals form either minimum-boiling or maximum-boiling azeotropes (1) with water:

1. Ethanol
2. Isopropyl alcohol
3. Methyl ethyl ketone
4. Ethyl acetate
5. Butyl alcohol
6. Toluene
7. Acetic acid
8. Hydrochloric acid
9. Hydrofluoric acid
10. Nitric acid
11. Formic acid

Scope of Problem

The industries using the listed chemicals can be found in a wide range of Standard Industry Codes including those targeted in DOE's Industries of the Future program. For example, in the Forest Products group, some companies in Massachusetts listed under SIC 2672 – Coated and Laminated Paper – use more than 4.0 million pounds of toluene in 1999 and most of these was disposed off by combustion in (regenerative) thermal oxidizers. No specific industry partners have been identified yet but those companies using thermal oxidizers may want to participate.

Objective

The objective is to identify “simple and economical” processes that can be employed by the small to intermediate businesses to effect recovery and recycling on-site. The recovery scheme should start with scrubbing with water to remove the chemical from the gas phase.

The following list includes standard methods that can be tweaked or otherwise redesigned to effect separation from water:

1. Extractive Distillation with Suitable Solvent
2. Azeotropic Distillation with Appropriate Entrainer
3. Membrane Distillation
4. Pressure Sensitive Distillation
5. Separation with Drying Agent(s)
6. Pervaporation

(1) Robert H. Perry and Don Green, Editors, "Perry's Chemical Engineering Handbook", 6th edition, McGraw-Hill, Inc. 1984.